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## FITNESS FUNCTION CALCULATION TECHNIQUE IN YAGI – UDA ANTENNAS EVOLUTIONARY DESIGN

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### ABSTRACT.

Yagi – Uda antennas is the one of most simple type of wire antennas in different applications. A design of these antennas turned out to be the complex problem. It is connected with complexity of definition of current distributions on antenna's vibrators. This currents distribution can be used for account of external and internal antenna parameters. These parameters are used for fitness function calculation, which allowing finding the optimum decision of designing problem. The chosen fitness function should include both external, and internal antennas parameters. Hallen's integral equation application for current distribution definition on Yagi – Uda antennas vibrators is considered in this paper. It is shown, that the examination of frequency dependences of input resistance and currents amplitudes distributions can in addition simplify a design of the antenna.

### INTRODUCTION

Modern computer-aided modeling tools permit to calculate external and internal antennas parameters. Most popular tool is NEC2 [1, 2]. The application of this software allows to simplify the decision of tasks of antenna design optimization. The main role in reduction of time of the optimization task decision is defined by a choice of fitness function. The large reduction of decision time can be achieved in a case, when fitness function includes parameters, which reflecting basic physical processes proceeding in the antenna. At a choice of such parameters it is desirable to use integrated antenna's parameters. Such parameters are antenna's complex input resistance, pattern width, side lobe level and so on. Besides at generation of an initial population it is necessary to take into account the theoretical and experimental results received earlier for a chosen antennas type. In another case received solution may be very far from optimal solution, or can not be realized. It can occur because the considered software uses the approximated laws of currents distribution in antennas vibrators. Thus the put task can overstep the bounds of methods applicability used at creation of this tool. Other reason of similar mistakes can become not enough detailed structure of fitness function. It can occur when fitness function includes only external or internal parameters.

As example of such fitness function can be considered function, which was used at the decision of optimization of the Yagi – Uda antennas construction problem, considered in [3]. In the given paper the design of the antennas from 14 elements ensuring work in a frequencies bandwidth near 12 percents is developed. Thus the thickness of antennas vibrators relied identical and equal 3 mms. But the analysis of experimental researches of such antennas shows, what even for the five-element antenna it is difficult to receive a pass band

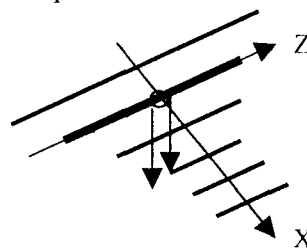


Fig. 1

Antennas construction

in 10 per cents [4]. It is necessary to use active vibrators of the special form or to increase their thickness for expansion of such antennas passband.

Besides it is necessary to note, that at such disorder of the vibrators sizes some vibrators will have the large complex part of entrance resistance. It will result that the current amplitude in them will be much less, than in vibrators, which length is close to half of working wavelength. Hence they will not influence to antennas pattern formation and can be excluded from the antenna construction.

### APPROACH DESCRIPTION

Let's consider a task in the following statement. There is the Yagi – Uda antenna in the free space, which consisting of  $N$  linear elements (fig. 1). Its active vibrator is coincided by a dot source, which located at its centre. The vibrators thickness is much less, than working wavelength. It is required to choose a method of currents distribution calculation on the antennas vibrators, which permit to have an opportunity to define its external and internal parameters.

The opportunity of two types integral equations application for the decision of the put task was investigated. It was shown, that the poklington's system of the integral equations does not permit to receive the steady solution of a considered problem. The current distribution on antennas vibrators was received on the basis of the decision of hallen's integral equations system:

$$\sum_{n=1}^N \int_{-l_n}^{l_n} J_{nz}(z') \frac{e^{-ikR_{pq}}}{R_{pq}} dz' = C_m \cos(\beta z) - \frac{iU_m}{60} \sin(\beta|z|), \quad (1)$$

Where  $z$  - arrangement coordinate of an auxiliary source

$z'$  - coordinate of integration point on the vibrator surface with number  $m$ ;

$l_n$  - length of the vibrator with number  $n$ ,

$U_m$  - the voltage amplitude stimulating in a backlash of the active vibrator,

$$R_{pq} = \begin{cases} \sqrt{(z'_n - z_m)^2 + D_{nm}^2}, & \text{if } z_m \notin L_n; \\ \sqrt{(z'_n - z_m)^2 + a^2}, & \text{if } z_m \in L_n; \end{cases}$$

$R_{pq0}$  - distance between a point of an auxiliary source and middle of the active vibrator.

The constant  $C_m$  can be found directly from (1) when  $z$  is equal to the 0. Using a designation

$$K_{mn} = \frac{e^{-ikR_{pq}}}{R_{pq}} - \cos(\beta z) \frac{e^{-ikR_{pq0}}}{R_{pq0}},$$

Transform expression (1) to the following

$$\sum_{n=1}^N \int_{-l_n}^{l_n} J_{nz}(z') K_{mn}(z, z') dz' = -\frac{iU_m}{60} \sin(\beta|z|)$$

decomposition of series:

$$J_{mz}(z') = \sum_{p=1}^P J_{mp} \left(1 - \frac{|z'|}{l_m}\right)^p \quad (2)$$

The input resistance of antenna is calculat

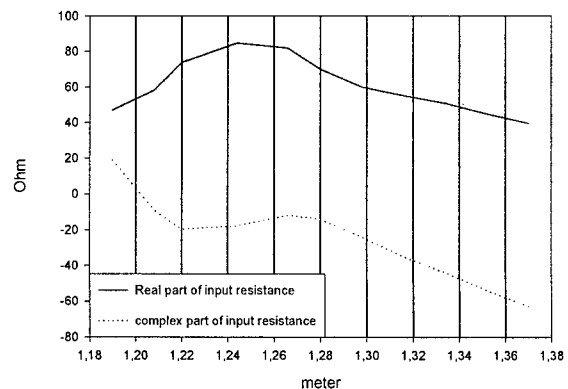


Fig. 2

$$Z_{entr} = U_m / J_m(0)$$

## EXPERIMENTAL RESULTS.

For the decision of the put task three harmonics in series (2) were used. The received currents distribution was used for calculate of antennas entrance resistance and its pattern in main planes. It was shown, that the pattern's form in E- plane changes insignificantly in the specified frequency range. But in the H- plane there are large changes of the pattern's form and side lobe levels. Also the large changes are tested by input resistance in the working frequency bandwidth. It is equal to the 39,7-j63,9 Ohm at the frequency 219 MHz, 70-j17 Ohm at frequency 235 MHz, and 49,3+j6 Ohm at frequency 250 MHz. Dependences of an active and complex components of antennas input resistance from working wavelength are shown in figure 2. Such character of entrance resistance changing specifies to resonant character of processes, which proceeding in the antenna. The abrupts of active and complex components of antennas input resistance in a working strip complicate its connection with feed line. These abrupts can be eliminated by introduction of the additional agreeing device into antennas construction. It will complicate a design of the antenna and can decries the working bandwidth.

Distribution of currents amplitudes at the centers of vibrators in a working frequencies bandwidth was investigated. It is shown, that the currents amplitudes on short vibrators of the considered antenna can be in fifty ore one hundred times less, than currents amplitudes in resonant vibrators in working frequency range. It allows making the conclusion that such vibrators can be excluded from antenna's construction.

Change of behavior of antenna entrance resistance in frequency range also was examined at increasing of vibrators thickness. To not leave from borders of applicability of a using method the vibrators by thickness of 6 mm were considered. The analysis of results shows, that in this case it is possible to reduce jumps of a complex component of antenna entrance resistance.

## CONCLUSION

Thus is shown, that the introduction in fitness function in [3] input resistance of the antenna would allow essentially changing a construction of the developed antenna. After examining the antennas construction, developed in [3], we can say that this antenna is not Yagi – Uda antenna, because the classic phase relationships between the vibrators currents are not required in this construction. In additional we note, that application of classic relationships between antennas elements sizes and distances between vibrators provided the reduction of calculation efforts.

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